



Animating a Human Body Mesh with Maya for Doppler Signature Computer Modeling

by Getachew Kirose

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14. ABSTRACT <p>The Maya software package has been used by researchers at the U.S. Army Research Laboratory (ARL) to create human body motion animation for the purpose of simulating the radar signature of a moving human target. This report describes how to use Maya's powerful graphics user interface (GUI) in order to create realistic frame-by-frame animation of a human mesh in walking motion. The examples presented here also include a human equipped with a rifle. These scenarios are an important part of the ARL modeling efforts in predicting the performance of radar technology for human target detection, tracking, and classification.</p>					
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1. Introduction

The U.S. Army is currently developing radar technology for concealed human target detection, tracking, and classification for both through-the-wall and foliage penetration applications. Modeling the radar signature of the human body is an important step in understanding the phenomenology and predicting the performance of the radar systems used in these applications. The U.S. Army Research Laboratory (ARL) has been active in developing computer models for the radar signature of stationary (1) or moving (2) people. Advanced computational electromagnetics (CEM) codes, such as Finite Difference Time Domain (FDTD) and Xpatch, were used in these simulations. Creating realistic meshes for these CEM codes is a major component of the modeling effort. This report describes the software tools employed in creating mesh animation that simulates human walking.

In order to obtain a computer-animated version of a human walking, I started with a human mesh in a basic position, such as the “fat” man or “fit” man (described in Dogaru et al. [1]), and repositioned it in successive frames that sampled the desired motion cycle. Two popular software packages for human body mesh repositioning are Varipose (3) and Maya (4). While Varipose works with voxel-based grids that contain a detailed model of every human body tissue, the program is fairly difficult to use and extremely time consuming (each frame can take about one day to generate on a desktop personal computer [PC]). On the other hand, Maya is a more flexible tool, allowing the manipulation of meshes in various formats, as well as the combination of multiple meshes. From a user’s perspective, Maya is easy to work with and enables the creation of a large number of frames for realistic motion animation in a very short time.

In this report, I introduce the Maya software package and describe the procedure used to generate the human mesh animation of walking motion. I present an overview of Maya in section 2. The animation procedure is described in section 3. In section 4, I show several human mesh animation results. I present the conclusions in section 5.

2. Overview

2.1 General Description of Maya

Maya is a commercial software product that provides a variety of powerful tools for three-dimensional (3-D) modeling, animation, rendering, etc. (5). Maya can be used to create convincing visual simulations of all sorts of objects interacting in the physical world. Maya

enables users to access the Maya Embedded Language (MEL) to write scripts that can help enhance productivity and customize the Maya user interface. I will give a brief introduction to the Maya user interface and the tools in the following sections.

2.2 Maya User Interface

The Maya user interface is a tool that enables a user to display and facilitate the manipulation of objects. It consists of tools such as menus, panels, windows, icons, etc. The menus and tools are discussed in detail in section 2.3. Figure 1 shows the Maya user interface.

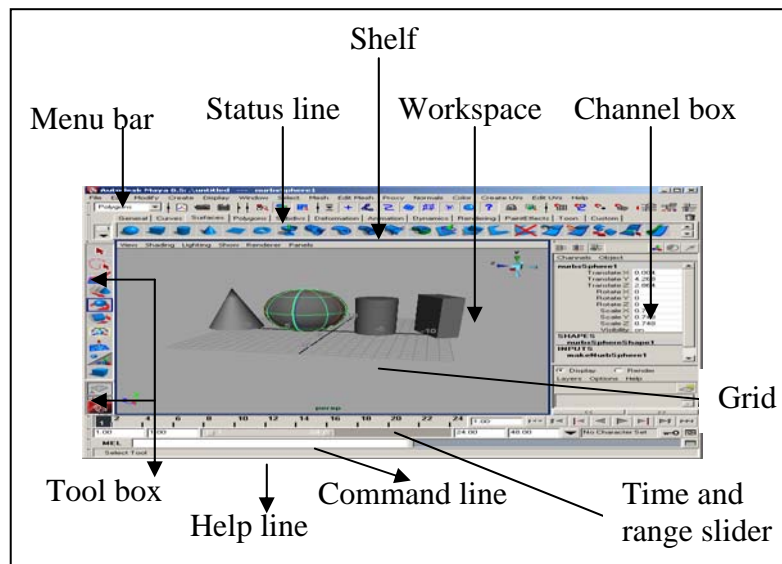


Figure 1. Maya user interface.

The *channel box* displays numerical information on the shape and the x , y , z position of an object. Besides using Maya transformation tools to make changes to an object's shape or position, one can also make these changes by entering the exact values into the appropriate fields of the channel box. The *Status line* consists of icons, which allow quick access to the most frequently used tools. The user's most frequently used items and customized tools can be stored in the *Maya shelf*. The *Help line* is used to obtain help tips for all tools. The *Command line* enables the user to enter MEL commands and the *Time and range slider* is used for setting key frames for animation.

The *Maya work space* is the central window of the Maya user interface, where the user can create meshes of objects, animate objects, etc. The work space has a menu bar at the left corner of the panel, which has menus that enable users to access tools and functions related to that specific panel.

The main modules in Maya are Animation, Polygon (Modeling), Dynamics, and Rendering. Each module has its own menu sets. Figure 2 shows the specific menus for animation and modeling modules.

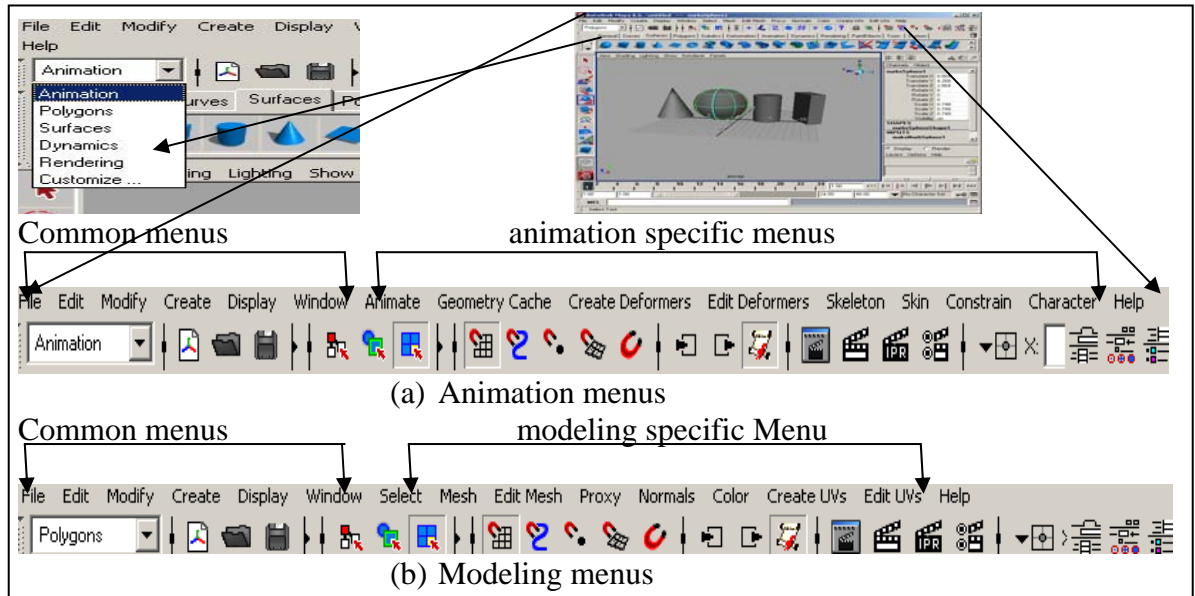


Figure 2. Modeling and animation menus.

2.3 Navigation and Transformation Tool

There are several useful tools that are common to all modules in Maya; the two most important are the navigation and transformation tools. The navigation tools are zoom, pan, and spin. To zoom, hold the Alt key and drag with the right mouse button. To spin, hold the Alt key and drag with the left mouse button. To pan, hold the Alt key and drag with the middle mouse button. The three transformation tools (move, scale, and rotate) are used for positioning, scaling, and viewing objects. The transformation tools are displayed on the left side of the work space and the user selects the tools to activate them. One can use these tools to transform a single object, many objects, or parts of objects. To move an object in one direction, drag the x , y , or z handle. To move and rotate an object freely, or scale uniformly, drag the center handle. Figure 3 shows the three color-coded transformation tools attached to the AK47 mesh used to create the man with weapon model. Red, green, and blue correspond to the x -, y -, and z -axis, respectively.

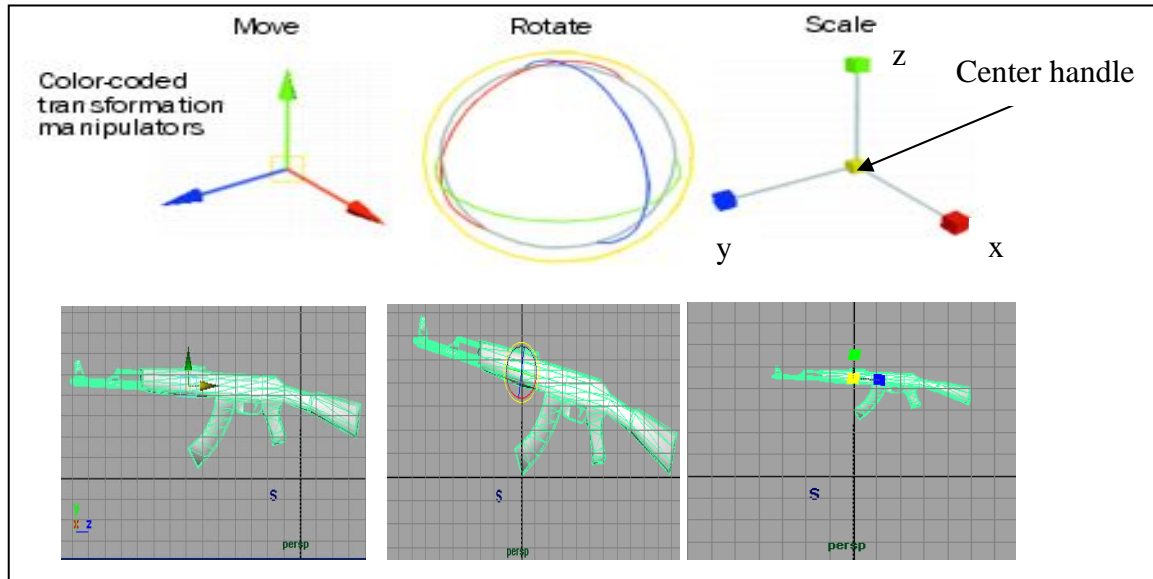


Figure 3. Color-coded transformation manipulators.

3. Animation Procedure

3.1 Character Setup

The process of preparing 3-D models with joints and skeletons for animation is called character setup. Depending on the model a user wants to animate, character setup can involve creating a skeleton, binding the model with the skeleton, setting constraints for particular animated attributes to restrict the range of motion, etc. In this report, I describe the creation of a walking cycle of a human model to simulate snap shots of a moving human. The steps involved in creating this animation are described in the following subsections.

3.1.1 Creating the Skeleton

The first step in this animation process is the creation of a skeletal hierarchy of *joints* that are connected together with *bones* to provide a structure for the human body that is essential for the animation of the human model. The user creates a skeleton in Maya by connecting a series of joints at points where the user wants the character to bend or twist. One can take advantage of the symmetry of the human body by creating a skeleton for just one side of the human model and using the Maya mirroring tool to create the skeleton for the other half. This saves time and ensures symmetry. When dealing with a human skeleton, one creates independent joint chains for each arm, leg, spine, etc., and then groups the chains together to create a single skeletal hierarchy.

To create a skeleton, click on “skeleton” on the main animation menu and then click on “Joint tool” to create joints on the human mesh where the mesh should bend and twist. Figure 4 shows a skeleton created for a human body mesh. Figure 4(a) shows the half section of the skeleton that was created manually and the other half, shown on figure 4(b), was created using the mirroring tool under the animation menu.

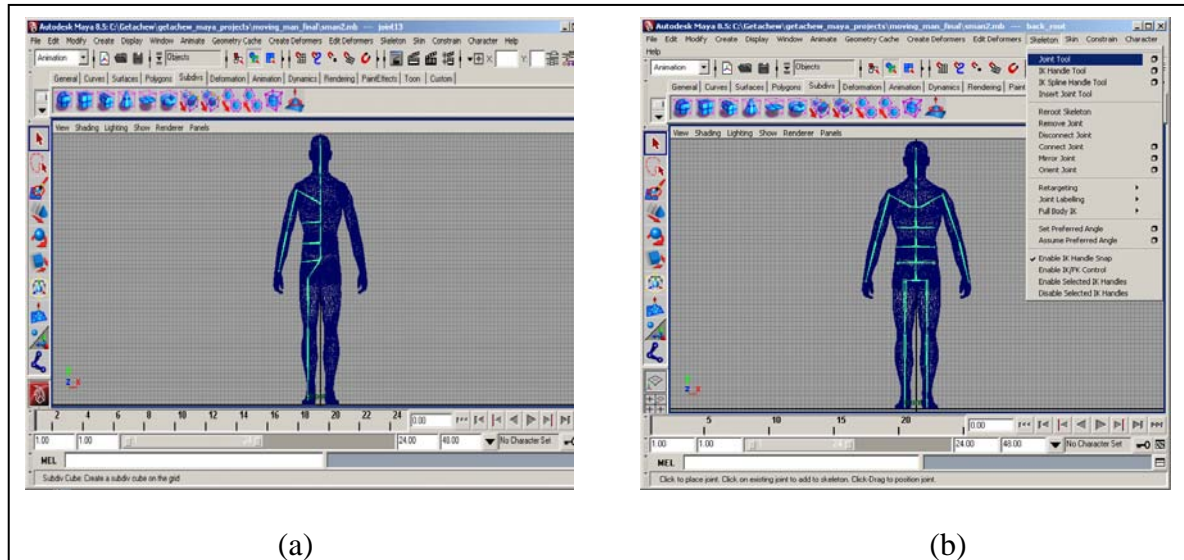


Figure 4. Creating of the skeleton.

3.1.2 Binding the Human’s Body Surface to the Skeleton

Binding is the process of attaching a skin (surface) to a skeleton. After creating a skeleton, the user needs to bind it to the surface of the human model so that both parts move together. The type of binding depends on the kind of animation needed. There are two types of bindings: smooth and rigid. Smooth binding is the best choice to create deformation effects such as muscle contraction and relaxation, because it allows gradual deformation influenced by several joints.

To bind a skeleton to the surface of a model, click “skin” on the main animation menu, then click “bind skin”, and finally click the “smooth bind” button. Figure 5 shows how the mesh looks like after the binding is complete.

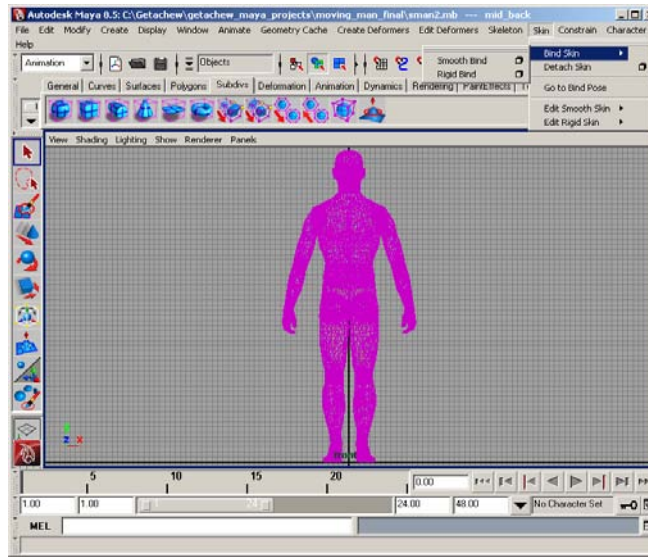


Figure 5. The human model after binding the skin (surface) to the skeleton.

3.2 Posing a Human Character Using Inverse Kinematics (IK) Technique

There are two techniques for posing a character. The first one is called Forward Kinematics (FK). In FK the user must rotate and translate each joint individually until each part of the body has been moved to the desired position. FK can be useful for simple arc motion, but it gets tedious and time consuming when animating a complex skeleton. Here, I used the second technique called Inverse Kinematics (IK) for posing the human model. IK lets the user create an extra control structure, called an IK handle, for certain joint chains such as arms and legs. The IK handle lets the user pose and animate the entire joint chain just by moving a single manipulator. For example, when moving a hand or a leg to a new position, the IK handle automatically rotates all the joints in the joint chain to accommodate the hand or leg's new positioning.

Once an arm or leg has been moved to a desired position, the user needs to set a key frame. Setting a key frame is the process that assigns a value to an object's attribute, such as translate, rotate, scale, etc., at a specific time. In order to create a 40-frame walking cycle, I keyed the start, middle, and end time frames and Maya automatically generated poses for the rest of the frames. Figure 6 shows the keyed positions at frame 1, frame 20, and frame 40.

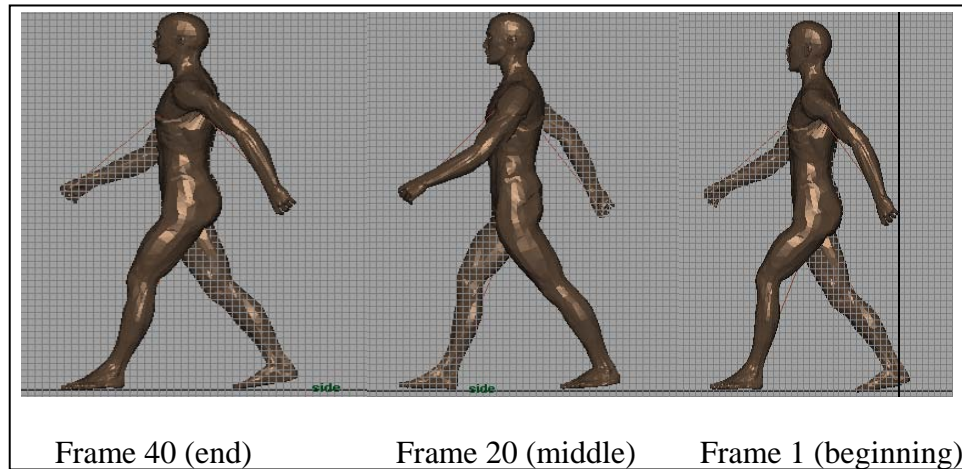


Figure 6. The poses for the beginning, middle, and end frames.

3.3 Tools to View the Scene Hierarchy and Make Changes to Your Animation

The Hypergraph and the graph editor are the two important tools for viewing the scene hierarchy and making some modifications to the animation. These tools are briefly explained in the following subsections.

3.3.1 The Hypergraph

The Hypergraph lets the user see how the nodes and their connections are organized in the scene and shows object hierarchies and dependencies. To select the Hypergraph from main menu, select “Window” and then “Hypergraph”. Each node has a unique name assigned to it when first created. On the Hypergraph, the nodes are connected using a line to show the relationship between the upper and lower nodes. This node hierarchy can be represented by a parent and child relationship. When the parent node is moved, rotated, or scaled, the child nodes underneath are also affected. The Hypergraph is useful for selecting an item in a much cluttered scene to rename or modify it. Figure 7 shows part of the Hypergraph for the animated human model.

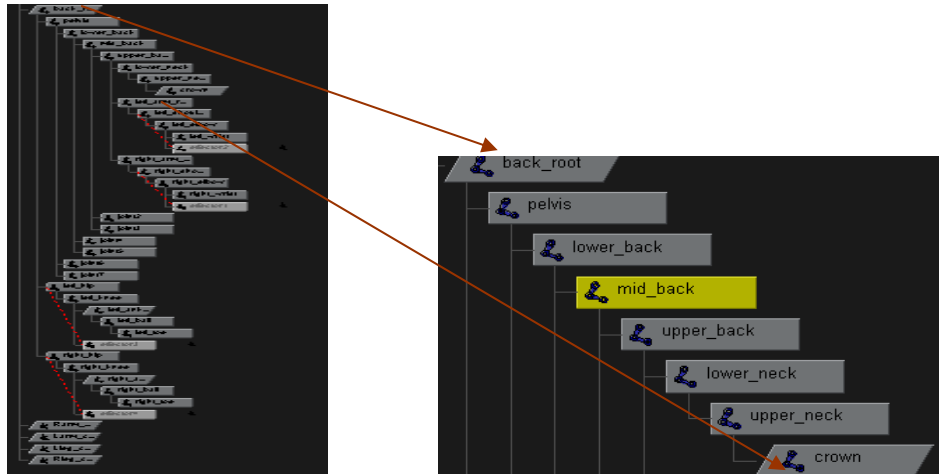


Figure 7. The Hypergraph.

3.3.2 The Graph Editor

This tool graphically represents the various animated attributes in a scene that are represented by curves called animation curves. Each animation curve represents the changes in value of an attribute during the animation. The graph editor can be used to make changes to the animation. In this case, if the animation does not display the smooth walk and arm swing one expects to see from a normal walk, the user can make a careful modifications and changes to the animation curves using the graph editor. Figure 8 displays the animation curves for a keyed attribute of the man's position. To edit animation curves using the graph editor, select "Window" on the main menu, go to "Animation Editors", and then select "Graph Editor". The graph editor then displays the animation curves for each of the keyed attributes of the man's position. The attributes for the man are listed on the left column, where the attributes of the selected transform node of the man are highlighted.

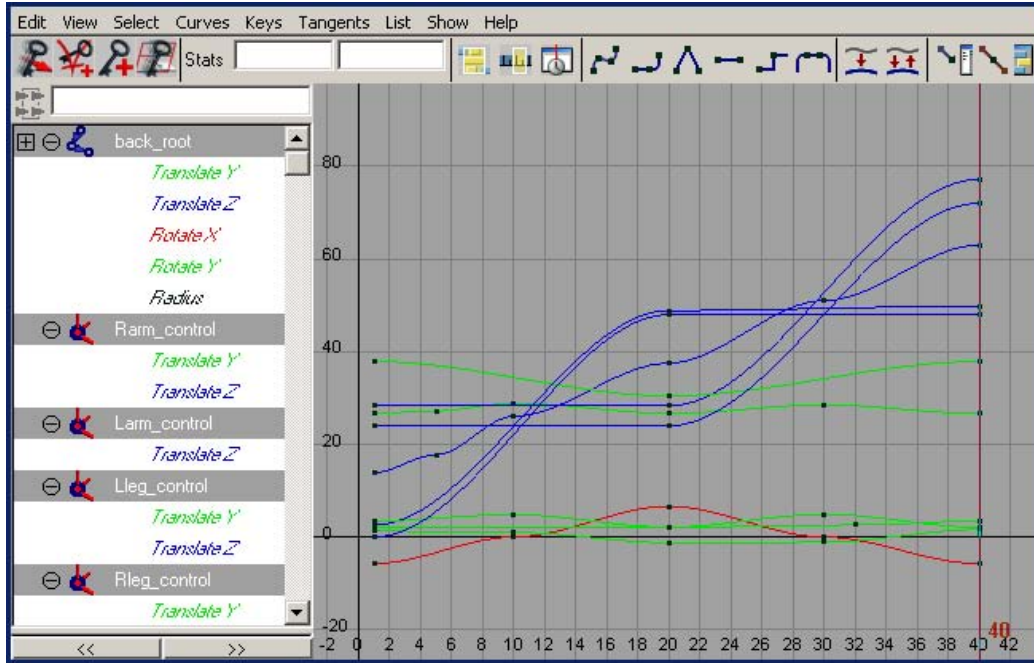


Figure 8. The graph editor.

The values on the vertical axis represent attribute values that can be used to animate the object, and the horizontal axis represent each of the 40 frames (time). Each curve shows how an attribute changes value during the animation. The value of an attribute at a particular time is given at each point on the curve. Points where the user has set keys are represented by black squares. One can modify an animation by using the move tool and middle mouse button to move a key point and the scale tool and the middle mouse button to scale selected key points closer together or further apart. One can select a curve or curves one wants to modify by clicking on the list of curves on the left column of the graph editor. This display makes the graphs uncluttered and easier to work with.

4. Results: Animation of a Walking Human Model

I animated a human body mesh for three different scenarios. I started with a basic human body mesh representing the “fit” man (1) in standing position. This mesh was obtained from a commercial Web site (6). In one animation scenario, the human moves in a natural walking motion cycle (figure 9). In the other two, the walking human carries an AK47 rifle in the port-arm position (figure 10) and the sling-arm position (figure 11), respectively. For each of these motion types, I created 40 frames in one complete walking cycle. Figures 9 through 11 show one frame of each arrangement in the perspective, front, and side views.

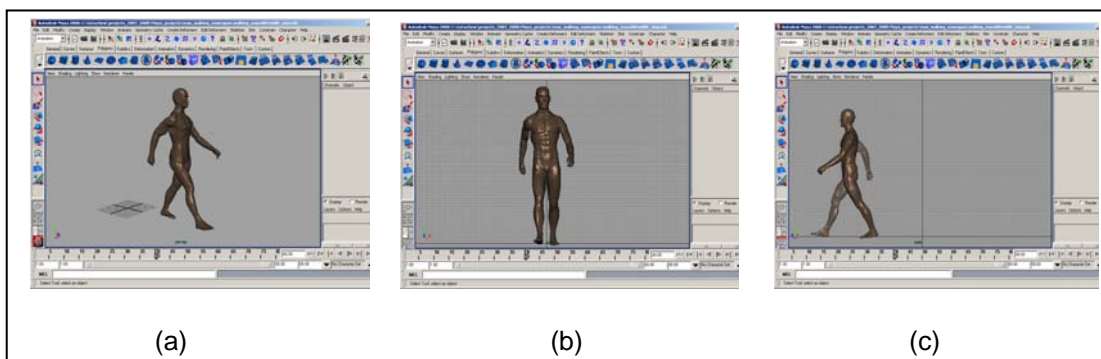


Figure 9. The perspective (a), front (b), and side (c) views of a walking man.

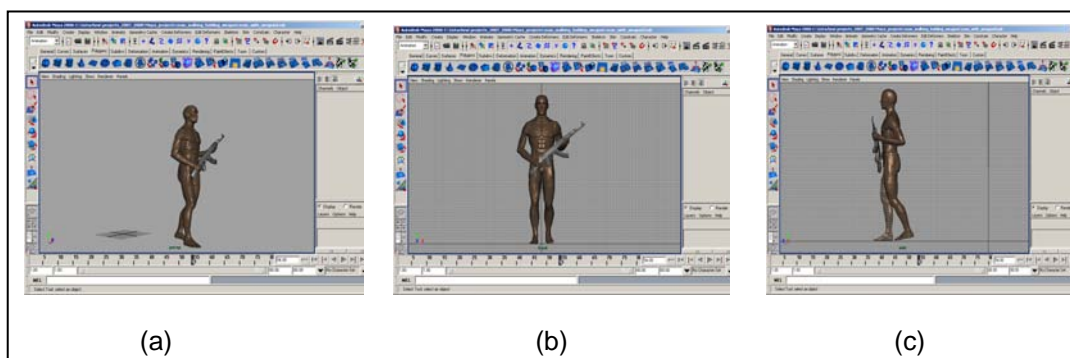


Figure 10. The perspective (a), front (b), and side (c) views of a walking man holding a weapon in port-arm position.

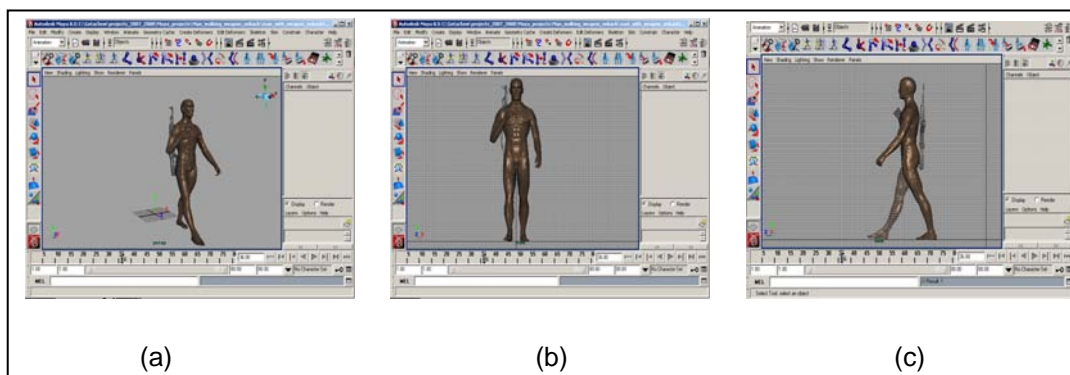


Figure 11. The perspective (a), front (b), and side (c) views of a walking man holding a weapon in sling-arm position.

5. Conclusions

In this report, I presented a general description of the Maya software package and demonstrated how the tools can be used to animate a human model. I showed that Maya is an easy to use tool, displaying a friendly GUI that enables the creation of many motion frames in a short time interval, as compared to other human mesh repositioning tools, such as Varipose, which are difficult to use and very time consuming. I also demonstrated that combining multiple meshes is possible in Maya. The resulting human body mesh animation is very realistic.

In section 4, I presented three examples of mesh animations of a walking human, with or without a rifle. These meshes can be fed into a CEM simulator in order to obtain the frame-by-frame radar response. This procedure closely models the operation of a pulse-Doppler radar. The resulting simulated data can be processed by algorithms designed to detect, discriminate, and classify human movers (2).

6. References

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List of Symbols, Abbreviations, and Acronyms

3-D	three-dimensional
ARL	U.S. Army Research Laboratory
CEM	computational electromagnetics
FDTD	Finite Difference Time Domain
FK	Forward Kinematics
GUI	graphics user interface
IK	Inverse Kinematics
MEL	Maya Embedded Language
PC	personal computer

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